

Claims

We claim:

1. A process for filtering water to remove hardness comprising the steps of:
 - (a) flowing water to be filtered into a first opening of a module of membranes adapted to selectively reject hardness causing salts;
 - (b) collecting a softened permeate from a permeate side of the membranes;
 - (c) collecting a retentate from a second opening of the module; and,
 - (d) periodically reversing the direction of feed flow through the module such that water to be filtered flows into the second opening of the module and retentate flows out of the first opening of the module.
2. The process of claim 1 wherein the module comprises a plurality of successive stages of varying membrane surface area.
3. A filtration process to remove hardness comprising the steps of:
 - (a) providing a membrane module comprising a plurality of successive stages and having a hardness rejection of at least 75% and an initial permeability greater than 0.1 gfd/psi;
 - (b) feeding feed water into the module feed inlet to flow feed water through the module in a single pass;
 - (c) withdrawing a retentate from the module outlet; and,
 - (d) withdrawing a permeate from the permeate outlet,
wherein the minimum feed/retentate velocity in any of the stages is between about 0.15 and 0.6 ft/s.
4. The process of claim 3 wherein the minimum feed/retentate velocity in any of the stages is between about 0.2 and 0.3 ft/s.

5. A process for filtering water to remove hardness comprising the steps of:
 - (a) flowing water to be filtered against a feed or retentate side of a module adapted to selectively reject hardness causing salts;
 - (b) collecting a softened permeate from a permeate side of the membranes;
 - (c) collecting a retentate from the module; and,
 - (d) adding carbon dioxide to the feed water before the feed water enters the lumens of the hollow fibre membranes.
6. The process of claim 5 wherein the carbon dioxide is added continuously to the feed water in amounts such that the Langelier Index is zero or slightly negative.
7. The process of claim 5 wherein the carbon dioxide is added to the feed water from time to time at times when the need for permeate is low and permeate is either not produced while carbon dioxide is added to the feed or permeate produced while carbon dioxide is added to the feed is discarded.
8. The process of claim 5 further comprising periodically reversing the direction of feed flow through the module and adding carbon dioxide to the water to be filtered while the water to be filtered flows into the module in a reverse direction.
9. The process of claim 1 further comprising adding carbon dioxide to the water to be filtered while the water to be filtered flows into the module in a reverse direction.
10. A nanofiltration or reverse osmosis apparatus adapted to remove hardness from a feed water comprising:
 - (a) a nanofiltration or reverse osmosis filtration module adapted to reject hardness and having a module feed inlet for introducing the feed

water, a module outlet for removing retentate containing hardness, and a permeate outlet for removing the treated permeate;

(b) a feed water passageway fluidly connected to the module feed inlet of the filtration module for introducing pressurized feed water to the module in a single pass;

(c) a controllable carbon dioxide addition system for injecting a fluid comprising carbon dioxide into the pressurized feed water having at least one outlet for removing the fluid; and,

(d) a carbon dioxide passageway fluidly connecting the carbon dioxide addition system and either the feed water passageway or the nanofiltration module.

11. The apparatus as claimed in claim 10 further comprising:

(a) a permeate passageway fluidly connected to the permeate outlet; and,

(b) a pressurized diaphragm tank for storing the treated permeate, having a tank inlet which is fluidly connected to the permeate passageway for receiving and removing the permeate.

12. The apparatus as claimed in claim 11 wherein the feed water is pressurized only by a municipal water supply.

13. The apparatus as claimed in claim 12 wherein the nanofiltration or reverse osmosis filtration module has a plurality of successive stages.